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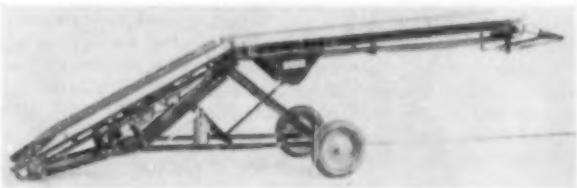

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OUR COVER PICTURE—*A Winter scene in New Jersey. Photo courtesy Freese Photo Co., New Brunswick, N. J.*

EFFECT OF PLANTING DATES ON YIELDS, TOTAL SOLIDS, AND FRYING AND CHIPPING QUALITIES OF POTATO VARIETIES[1]

ROBERT V. AKELEY,[2] FREDERICK J. STEVENSON[2] AND DONALD MERRIAM[3]

During the last decade most potato growers have increased yields per acre by using ample fertilizer and better equipment and materials for the control of insects and late blight. Such practices may have increased rates of growth within certain periods, but most increased yields have resulted from the extension of the growing season well into September or until frost killed the vines.

Under present-day cultural practices it is advisable to kill the potato vines 10 to 15 or even 20 days before harvesting by rotobeating, chemical sprays, or a combination of these, so that the tubers will mature sufficiently to be handled without bruising. Immature tubers, low temperatures at harvest time, and field frost are the main factors causing shrinkage of potatoes during harvest and subsequent storage. For these reasons it is important that growers in northern Maine and in similar areas do everything possible to produce a profitable crop by September 1 and by so doing avoid losses inherent in late to very late harvesting. Earlier planting of potatoes should alleviate some of these difficulties. To determine the effects of date of planting on yield, total solids, and quality of chips and french fries, 8 varieties of potato were planted on 4 dates in 3 years.

METHODS AND MATERIALS

The data reported in this paper were obtained from field tests conducted in 1950, 1951, and 1952 on Aroostook Farm, Presque Isle, Maine. A randomized split block with 4 replications was used as the experimental design. A single plot consisted of 25 plants spaced 10 inches apart in rows 34 inches apart. The seed pieces ranged in weight from 1.5 to 2 ounces. An 8-16-16 fertilizer containing 2 per cent magnesium was applied at the rate of approximately 1,400 pounds per acre. Standard cultural methods for the area were used. The dates of planting in each of the 3 years were approximately May 5, May 15, May 25, and June 4. In a few cases the dates differed from one year to the next by not more than 1 day. The plants in all tests were allowed to grow until maturity or until the first light frost occurred, usually about the middle of September.

The potatoes were graded to U.S. No. 1 size and weighed. Samples of 20 tubers weighing about 8 ounces each were taken from each plot for determination of total solids and testing cooking qualities. The specific gravity readings were made soon after the tubers were graded by weighing the 20-tuber samples in air and water. The percentages of solids were calculated from these data. The tubers then were dried and placed in storage at a constant temperature of 40° F. From harvest to time of storage care was taken to keep the tubers at a temperature not less than 40°.

[1]Accepted for publication June 15, 1955.

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After approximately 3 months in storage at a constant temperature of 40° F. the tubers were reconditioned for 35 days or more in a temperature of 60° F. After reconditioning, french fries and chips were made from the tubers.

For french fries 2 plugs, ½ inch square, were taken from the center of each of 5 tubers. The 10 plugs were cooked in pure vegetable oil (Primex) in a 2-tray deep-fat cooker with thermostatic control. During the frying the temperature dropped very little. The french fries were judged for texture and color. Texture ratings were made by applying pressure with the index finger to the fries. The soggy fries were placed in class 1; intermediates, class 2; and the mealy ones in class 3. They were arranged in 7 color classes indicating degree of browning; class 1, a very dark brown, to class 7, a very light brown. The entire procedure used in this test is the same as that used in Maine by some firms that make frozen french fries for the commercial trade.

For chips, 2 slices slightly less than ¼-inch thick were cut from the center of each of 5 tubers. The 10 slices were rinsed in water to remove excess starch, blotted dry with paper towels, and then cooked in Primex at a temperature of 335° to 345° F. until bubbling ceased. The chips were judged for color and arranged in the same 7 color classes used in classifying the french fries. In each of the 3 years of testing the same 2 persons judged both the french fries and the chips. They came to an agreement on each sample before the record was made.

Results

The average yields of the 8 varieties of potato planted on 4 dates in 3 years are given in table 1. Kennebec yielded 571 bushels of U.S. No. 1 potatoes per acre for an average of the 12 tests. The differences between the yield of Kennebec and all the other varieties except Green Mountain were highly significant and Kennebec outyielded Green Mountain significantly. Irish Cobbler, the earliest variety in the test, produced the lowest yield. It also showed the lowest percentage increase in yield for the May 5 as compared with the June 4 planting. Sebago, the latest maturing variety, showed the greatest percentage increase, indicating that early planting of a late maturing variety is highly desirable. The yields of all varieties in the dry season of 1952 were lower than the corresponding yields of 1950 and 1951. The interactions between varieties and years and between varieties and dates of planting were highly significant.

There was no significant difference between the 3-year means for the 8 varieties planted May 5 and May 15 but the differences between the yields for these two dates of planting and the two later dates were highly significant. The average yield of 542 bushels per acre for the May 5 planting was 152 bushels or 28 per cent more than for the June 4 planting. Within the years the differences were similar: the differences between yields for dates of planting were highly significant. Highest yields occurred for the earliest date of planting and yields decreased with delay in planting. The exceptions were in 1950 and 1951 when the mean yields for the May 15 planting exceeded that for the May 5. The outstanding difference between date means occurred in the dry year 1952 when the yield for the earliest planting was 513 bushels and that for the latest was 242 bushels per acre, an increase in favor of the earliest

TABLE 1.—*Effect of planting dates on mean yields per acre of U.S. No. 1 tubers of 8 varieties of potato grown at Presque Isle, Maine, 1950-1952.*

Variety or Group	Yield for Indicated Planting Date					May 5 Increase over June 4
	May 5	May 15	May 25	June 4	Mean	
3-Year Individual Variety Mean[1]	Bus.	Bus.	Bus.	Bus.	Bus.	Per cent
Irish Cobbler	484	471	395	394	435	22.8
Sebago	556	539	436	318	463	74.8
Chippewa	559	570	444	400	494	39.8
Katahdin	540	487	421	342	448	57.9
Teton	589	563	501	411	516	43.3
Mohawk	566	562	457	340	481	66.5
Kennebec	654	625	546	459	571	42.4
Green Mountain	560	577	546	454	557	43.2
1950 Mean[2]	523	560	490	476	512[3]	9.9
1951 Mean[2]	589	621	537	452	575[3]	52.4
1952 Mean[2]	513	466	377	242	400[3]	112.0
3-Year Mean[4]	542	549	468	390	496	28.0

[1]L.S.D. at 1 per cent level between varieties for 3 years 27 bushels
[2]L.S.D. at 1 per cent level between dates any one year 42 bushels
[3]L.S.D. at 1 per cent level between years 55 bushels
[4]L.S.D. at 1 per cent level between dates for 3 years 24 bushels

planting of 112 per cent. The means for years differed significantly. In 1951 a season of sufficient moisture, the yield of 575 bushels per acre was highest and in 1952, a very dry season, the yield of 400 bushels was lowest.

Date of planting affects not only the yields but also the percentage of total solids in potatoes and percentage of total solids in turn affects the cooking quality. The averages for total solids expressed in calculated percentages for 8 varieties planted on 4 dates in 3 years are given in table 2. Mohawk and Green Mountain each with an average of all tests of 20.3 per cent of total solids were significantly higher than the other 6 varieties. Irish Cobbler and Kennebec were similar in total solids and higher than Katahdin or Teton. Chippewa was lowest.

Seasonal conditions affected varieties differently. In 1950 Green Mountain showed 21 per cent solids, Mohawk 20.7 and Irish Cobbler 19.2; but in 1952, Irish Cobbler had 19.5 per cent, Mohawk 19.0 and Green Mountain 18.9. Seasonal conditions also affected the results from the different dates of planting. In 1950 the mean for all varieties was 20 per cent solids for the May 5 plantings which was significantly higher than the percentage for the other three dates, but in 1951 there were no significant differences between the means for the first three dates, but they were all higher than the last date of planting. The 3-year means for all varieties shows that the percentages of solids in the potatoes resulting from the plantings on May 5 were significantly higher than for any of the other 3 dates of planting and that the June 4 planting produced tubers with the lowest percentage of solids

TABLE 2.—*Effect of planting dates on the calculated*[1] *percentages of solids of 8 varieties of potato grown at Presque Isle, Maine, 1950-1952.*

Variety or Group	Percentage of Solids for Indicated Planting Date					May 5 Increase over June 4
	May 5	May 15	May 25	June 4	Mean	
3-Year Individual Variety Mean[2]	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Irish Cobbler	19.9	19.2	19.1	19.0	19.1	4.7
Sebago	18.7	18.4	17.9	17.4	18.1	7.5
Chippewa	17.5	17.2	17.0	16.5	17.0	6.1
Katahdin	19.1	18.4	18.4	18.3	18.6	4.4
Teton	18.9	18.0	18.5	17.8	18.3	6.2
Mohawk	20.7	20.7	20.3	19.4	20.3	6.7
Kennebec	19.4	18.8	19.0	18.0	18.8	7.8
Green Mountain	21.2	20.3	20.3	19.3	20.3	9.8
1950 Mean[3]	20.0	19.2	19.2	18.8	19.3[4]	6.4
1951 Mean[3]	19.2	19.1	19.3	18.7	19.1[4]	2.7
1952 Mean[3]	19.1	18.3	17.9	17.1	18.1[4]	11.7
3-Year Mean[5]	19.5	18.9	18.8	18.2	18.8	5.5

[1]Percentage of solids calculated from specific gravity.
[2]L.S.D. at 1 per cent level between varieties for 3 years 0.3
[3]L.S.D. at 1 per cent level between dates any one year 0.6
[4]L.S.D. at 1 per cent level between years 0.2
[5]L.S.D. at 1 per cent level between dates for 3 years 0.3

It was shown that potatoes should be planted early if the best yields and the highest percentages of solids are to be obtained. Color of chips is also affected by date of planting as can be seen by the data in table 3. The chips were rated according to the degree of browning as indicated in the No. 1 footnote to the table. Classes 4 and 5 are preferred by the trade although classes 6 and 7 are not objectionable. Classes 1, 2, and 3 are discriminated against and could not be sold unless mixed sparingly with chips having a desirable color.

The chips made from Kennebec had a good color regardless of the date of planting although the chips from the May 5 planting were lighter than those from June 4. Irish Cobbler had a mean for all 4 dates of 4.1 but the means of all the others were less than 4 or too dark in color for high quality chips. Green Mountain was exceptionally low with a mean rating of 1.9. Chips made from tubers of all varieties had better color when the planting date was May 5 rather than June 4, and the color of those made from Green Mountain and Mohawk was more than 50 per cent better. The color of the chips varied from year to year. In 1950 and 1951 only Kennebec had a class mean better than 4 but in 1952 the means of all varieties except Mohawk and Green Mountain were in class 4 or higher. The 3-year means for planting dates of the 8 varieties are all below 4 but the difference between the May 5 and the June 4 planting is highly significant. From the foregoing it is apparent that, of the 8 varieties tested, the chips made from tubers of Kennebec and Irish Cobbler had acceptable color when planted at 4 dates in the 3 years in which the tests were made.

TABLE 3.—*Effect of planting dates on color of chips of 8 varieties of potato grown at Presque Isle, Maine, 1950-1952.*

Variety or Group	Color Ratings[1] for Indicated Planting Date					May 5 Increase over June 4
	May 5 Class	May 15 Class	May 25 Class	June 4 Class	Mean Class	
3-Year Individual Variety Mean[2]	No.	No.	No.	No.	No.	Per cent
Irish Cobbler	4.5	4.4	3.9	3.5	4.1	28.6
Sebago	3.8	3.5	3.7	3.1	3.7	22.6
Chippewa	3.7	3.7	3.7	3.1	3.6	19.4
Katahdin	3.9	3.5	3.3	2.9	3.4	34.5
Teton	3.3	3.4	3.0	2.6	3.1	26.9
Mohawk	3.8	3.5	2.9	2.5	3.2	52.0
Kennebec	5.6	5.1	4.6	4.3	4.9	30.2
Green Mountain	2.2	2.1	1.7	1.5	1.9	46.7
1950 Mean[3]	3.1	2.9	3.1	2.5	2.9[4]	24.0
1951 Mean[3]	3.6	3.3	3.1	3.1	3.3[4]	16.1
1952 Mean[3]	4.8	4.8	3.8	3.2	4.2[4]	50.0
3-Year Mean[5]	3.8	3.7	3.4	2.9	3.5	31.0

[1]Color Ratings

Class	Degree of browning
1	Very deep
2	Deep
3	Medium deep
4	Medium
5	Medium light
6	Light
7	Very light

[2]L.S.D. at 1 per cent level between varieties for 3 years .27
[3]L.S.D. at 1 per cent level between dates any one year .53
[4]L.S.D. at 1 per cent level between years .23
[5]L.S.D. at 1 per cent level between dates for 3 years .31

The french fries were judged for color and texture. The data for color are found in table 4. The color classes used in judging the french fries were the same as those used for grading the chips. In commercial production french fries rating 5 or higher, before freezing, are preferred. Kennebec, with a mean of 5.1 was the only variety high enough to qualify for the 3 years and the 4 planting dates. Irish Cobbler, Sebago, Chippewa, and Katahdin were in class 4, Teton and Mohawk in class 3 and Green Mountain in class 2. However, the color of french fries of all varieties was higher for the May 5 plantings than for the June 4 plantings.

The texture ratings of the french fries for 1950 and 1951 are given in table 5. The differences between the means for varieties, dates of planting or years grown are small. In general the texture of all the french fries made in both years was acceptable. Ninety-five per cent of them were mealy. It can be concluded that date of planting or year grown had little effect on texture of french fries.

DISCUSSION AND SUMMARY

Effects of date of planting on yields, total solids and quality of chips and french fries were studied with 8 varieties of potato planted

TABLE 4.—*Effect of planting dates on color of french fries of 8 varieties of potato grown at Presque Isle, Maine, 1950-1952.*

Variety or Group	Color Ratings[1] for Indicated Planting Date					May 5 Increase over June 4
	May 5 Class	May 15 Class	May 25 Class	June 4 Class	Mean Class	
3-Year Individual Variety Mean[2]	No.	No.	No.	No.	No.	Per cent
Irish Cobbler	4.6	4.6	4.3	3.9	4.4	17.9
Sebago	4.1	4.3	4.1	3.8	4.1	7.9
Chippewa	4.4	4.3	4.4	4.0	4.3	10.0
Katahdin	4.3	4.2	3.8	3.9	4.1	10.3
Teton	3.7	3.8	3.5	2.7	3.4	37.0
Mohawk	3.8	3.4	3.3	2.5	3.3	52.0
Kennebec	5.3	5.0	5.1	4.8	5.1	10.4
Green Mountain	2.4	2.4	2.1	1.9	2.2	26.3
1950 Mean[3]	3.9	3.7	3.8	3.3	3.7[4]	18.2
1951 Mean[3]	3.6	3.5	3.4	3.5	3.5[4]	2.9
1952 Mean[3]	3.8	4.7	4.3	3.5	4.1[4]	8.5
3-Year Mean[5]	4.1	4.0	3.8	3.4	3.8	17.1

[1]See footnote 1, table 3 for color ratings.
[2]L.S.D. at 1 per cent level between varieties for 3 years .25
[3]L.S.D. at 1 per cent level between dates any one year .41
[4]L.S.D. at 1 per cent level between years .07
[5]L.S.D. at 1 per cent level between dates for 3 years .24

TABLE 5.—*Effect of planting dates on the texture of french fries made from 8 varieties of potato grown at Presque Isle, Maine, 1950 and 1951.*

Variety or Group	Texture Ratings[1] for Indicated Planting Date					French Fries in Mealy Class
	May 5 Class	May 15 Class	May 25 Class	June 4 Class	Mean Class	
2-Year Individual Variety Mean	No.	No.	No.	No.	No.	Per cent
Irish Cobbler	3.0	3.0	3.0	2.7	2.9	97
Sebago	2.4	2.5	2.6	2.8	2.6	86
Chippewa	2.7	2.7	2.8	2.9	2.8	92
Katahdin	2.9	2.9	2.9	2.9	2.9	96
Teton	2.8	2.8	2.9	2.8	2.8	94
Mohawk	2.9	2.9	3.0	3.0	3.0	98
Kennebec	3.0	3.0	3.0	3.0	3.0	100
Green Mountain	2.9	3.0	2.9	2.9	2.9	98
1950 Mean	2.8	2.8	2.9	2.8	2.8	95
1951 Mean	2.9	2.8	2.9	2.9	2.9	95
2-Year Mean	2.8	2.8	2.9	2.9	2.9	95

[1]Texture ratings — 1, soggy; 2, intermediate; and 3, mealy.

on 4 dates, in 3 years — 1950, 1951, and 1952, at Presque Isle, Maine. Yields of the plots planted May 5 exceeded those of June 4 by 22 to 75 per cent depending on the variety. It is evident that potatoes in northern Maine should be planted as early as possible if the varieties tested are to produce maximum yields. The percentages of total solids were on the average highest for the earliest dates of planting and for this reason early-planted potatoes should produce tubers with higher cooking quality, which will make them more valuable for processing and for the production of by-products.

Chip quality is closely related to color, and french fry quality to color and texture. Kennebec and Irish Cobbler produced acceptable chips and french fries, regardless of the date of planting. The chips and french fries of the other varieties were more desirable if made from the potatoes produced in the earliest planted plots. Many of the chips and french fries made from potatoes produced in the plots planted June 4 were too dark to be acceptable to the trade. Differences occurred between years as to lightness of color of chips and french fries.

The texture of all french fries made in the years 1950 and 1951 was acceptable. Ninety-five per cent of them were mealy. It can be concluded that date of planting or year grown had little effect on the texture of french fries.

RADIATION AND RESISTANCE OF TUBERS TO ROT[1]

PAUL E. WAGGONER[2]

Sprouting and shrinkage of potato tubers can be inhibited by ionizing radiation (6). Doses of 10-20 Kr (thousand röentgens) give practical control of loss from sprouting and shrinkage for periods of more than 1 year. As yet there have been no studies of the effect of radiation upon another type of loss, the loss from rots caused by bacteria and fungi. Since rot can cause greater short term loss than sprouting or shrinkage (4), rot as well as sprouting must be studied.

An agent can change the amount of rot by changing the amount of bacteria or fungi on the tuber or by changing the tuber's resistance. Ten to 20 Kr will not kill most of the bacteria and fungi on the tuber. Therefore, the effect of radiation upon resistance is the critical factor.

Final evaluation of the effect of radiation upon resistance to rot must await large scale experimentation or commercial experience because of the variety of storage conditions and inoculum potentials that will be encountered. However, small scale experiments concerning characteristics of potato tubers that control resistance to rot are reported here. From these a prediction concerning radiation and resistance can be made.

MATERIALS AND METHODS

Size B Katahdin tubers harvested in 1954 were stored at 45°. Tubers were exposed to gamma-radiation from Co^{60} at an intensity of 5-6 Kr/min. and returned to 45° storage until examined.

Erwinia carotovora, soft rot bacteria, and *E. atroseptica*, black leg bacteria, were obtained from Dr. B. A. Friedman and their identity verified by ability to form acid from alcohol (1). Inoculum consisted of a water suspension of washed cells grown for 24-48 hours in shaken nutrient broth. *Fusarium oxysporum* f. *lycopersici* was employed as a saprophyte. The fungus was grown in casamino acids medium and inoculum prepared as above.

EXPERIMENTAL

Radiation might increase or decrease tuber resistance to rot as it alters resistance to other plant diseases (7). As an exploratory experiment sterile slices from tubers irradiated 16 days before were placed in petri dishes and sprayed with *E. atroseptica* and *E. carotovora* cells. After 48 hours at 30° C. the check slices were almost completely macerated. Slices that had received 20 and 80 Kr were also severely macerated. Had a large increase in resistance been caused by radiation it could have been seen in this experiment. However, none occurred. On the other hand, a decrease in resistance could not possibly have been seen because the checks were so severely attacked. Therefore, the inference is made that no increase in resistance is caused by radiation, but a decrease may or may not be caused.

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Other experiments were run to detect any decrease in resistance indirectly. This was done by studying the effect of radiation upon three factors that could be involved in resistance to rot: diffusion of nutrients from cut tubers, formation of wound periderm, and maceration.

Ultra-violet radiation has been shown to decrease the resistance of tuber slices to saprophytic *Fusaria* by causing diffusion of nitrogenous nutrients from the washed slices (3). When washed and unwashed slices of potatoes that received 0, 20, and 80 Kr 60 or 67 days before, were inoculated with *F. oxysporum* f. *lycopersici*, much heavier growth occurred on the unwashed slices following incubation at 22.5°. However, no large effect of radiation appeared. When similar slices were incubated on a nitrogen-free agar medium (3), inoculated with *E. carotovora*, more nitrogenous compounds diffused from unwashed than washed cells as shown by the zone of bacterial growth. No large differences appeared due to radiation. Summarizing, these experiments predict no change in resistance due to diffusion of nutrients suitable for saprophytes as a result of irradiation 60-67 days before wounding.

Wound periderm formation is the part of the healing process that is necessary to prevent infection (8). Chemical sprout inhibitors have already been shown to slow down periderm formation and decrease resistance to *Fusaria* (2). Periderm formation is essentially cell division; therefore, inhibition of periderm formation may be concomitant with sprout inhibition by radiation. Sawyer *et al.* (5) found no inhibition of "healing" by doses up to 12.5 Kr. In our experiments slices were cut from tubers that had received 0, 20, or 80 Kr 49-67 days before. After incubating in moist chambers for 3 days at room temperature or 22.5°, free hand sections were cut and periderm formation estimated in terms of cell divisions (Table 1). Slices from tubers that had received 20 or 80 Kr consistently produced less periderm than the non-irradiated checks. Hence, at doses at or just above those employed for sprout inhibition, periderm formation or wound healing is inhibited, and possibly susceptibility to wound infection will be increased.

TABLE 1.—*Periderm formation in 3 days in slices from size B Katahdin potato tubers.*

Days from Irradiation to Wounding	Incubation Temperature	Number of Cell Divisions		
		0 Kr	20 Kr	80 Kr
49	Room	10, 6[1]	0, 1	0, 0
		8, 8	0, 0	2, 3
		15, 7	2, 4	0, 0
		5, 5	4, 0	0, 0
		7, 6	1, 0	0, 0
60	22.5° C.	4, 4	2, 1	1, 1
		4, 5	2, 2	1, 0
67	22.5° C.	2, 4	2, 3	0, 0

[1]Number of cell divisions at 2 locations on 1 section.

Following infection by bacteria, rot progresses by maceration. An experiment was conducted to determine whether 0, 20, or 80 Kr altered resistance to this stage of disease development. Twenty-seven days after irradiation 4-cm. long tuber plugs were cut aseptically with a size 4 cork borer. The plugs were placed in sterile test tubes plugged with cotton. Six of each lot were set in 1 ml. of *E. atroseptica* and 6 in 1 ml. of *E. carotovora* inoculum. After 1 day at 23° and 3 days at 30° the height to which maceration had extended was measured (Table 2). The experiment was repeated 35 days after irradiation with 2 days incubation at 30° (Table 2). Maceration was more severe in the second experiment, but no significant differences caused by radiation were seen.

TABLE 2.—*Mean height to which E. atroseptica (A) and E. carotovora (C) macerated plugs of Katahdin potatoes.*

Experiment	A			C		
	0 Kr	20	80	0	20	80
1	0.9 Cm	1.1	0.9	0.5	0.6	0.7
2	2.2	1.9	2.1	2.8	2.3	2.9

CONCLUSIONS

Sprout-inhibiting doses of ionizing radiation do not increase resistance to infection of wounds by bacteria.

Diffusion of nutrients from wounds, periderm formation, and maceration are processes important in the initiation and development of rot. Only periderm formation was affected by radiation in our experiments. Periderm formation is noticeably inhibited at doses at, or just above, those suggested for sprout inhibition. Therefore, increased rot could occur in irradiated potatoes under certain conditions of inoculum, wounding, and atmosphere. Whether or not these conditions occur frequently will not be known until large numbers of tubers have been irradiated under a variety of conditions.

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THE EFFECT OF 2,4-D AND MALEIC HYDRAZIDE ON SPROUTING, YIELDS AND COLOR IN RED McCLURE POTATOES[1]

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In recent years, studies have shown the effects of various growth regulating chemicals on Red McClure potatoes (12, 13, 24, 25, 27, 31). This paper is a continuation of the general plan to study the effect of growth-regulating chemicals on the composition and metabolism of potatoes. The object of the present paper is to report changes produced by 2,4-D and maleic hydrazide in sprout weights, yields, and skin color in Red McClure potatoes.

INTRODUCTION AND LITERATURE REVIEW

Chemical Treatments to Prevent Sprouting of Potatoes in Late Storage

There are two techniques which have been used to prevent sprouting of potatoes in late storage. These are:

(1) Direct Treatment of Tubers after Harvest
(2) Spraying of Plants before Harvest.

The direct treatment of tubers after harvest has the advantage that only tubers of market size need be treated and those smaller than market size (less than 2¼ inches) may be separated out for seed. The whole seed fraction of the crop is lost when the plants are sprayed before harvest (15). Spraying of plants before harvest is easier and cheaper than treatment of tubers after harvest and there probably is less of a residue problem.

(1) *Tuber Treatment Following Harvest*

A review of the literature, covering the period 1942-1954, on tuber treatment to prevent sprouting indicates that the following compounds have been used: 1-chloronaphthalene (6), 1-cyclohexyloxynaphthalene (1), ethyl ester of indoleacetic acid (35), ethyl ester of 1-naphthylacetic acid (35, 38), 1-isoamylnaphthalene (18), isopropyl ester of 2,4,5-trichlorophenoxyacetic acid (33), isopropyl phenyl carbamate (5, 6, 9, 28, 30), methyl ester of 2-furylacrylic acid (38), methyl ester of indoleacetic acid (6, 35), methyl ester of 1-naphthylacetic acid (6, 8, 9, 10, 28, 34, 35), methylnaphthylmethylether (6, 8), 1-naphthylacetic acetonitrile (35), 1-naphthylacetic acid (20), phenylurethan (9, 28), potassium salt of 2-furylacrylic acid (38), potassium salt of 1-naphthaleneacetic acid (38), sodium salt of 2,4-dichlorophenoxyacetic acid (34), sodium salt of maleic hydrazide (3, 6), sodium salt of 1-naphthylacetic acid (7), sodium salt of 2,4,5-trichlorophenoxyacetic acid (7, 33), terpineol (6), tetrachloronitrobenzene (5, 6, 8, 9, 10), and trichloronitrobenzene (2).

A detailed evaluation of remarks made by authors on the above list of chemicals indicates that isopropylphenylcarbamate (IPC) is probably

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the most effective sprout inhibitor tested to date, when applied on the tubers. Two other materials, the potassium salt and methyl ester of furylacrylic acid appear to be nearly as good sprout inhibitors as IPC but cause off-flavors in the skin. The 1-naphthaleneacetonitrile in combination with a growth inhibitor, of the blastokaolin type, has been reported to be unusually effective. The sodium salt of 2,4-D has been reported to be only a weak inhibitor of sprouting. All other compounds in the above list have been reported as being effective sprout inhibitors, at least equal to the methyl ester of 1-naphthaleneacetic acid.

Isoamylnaphthalene and cyclohexyloxynaphthalene have been reported to be sprout accelerators.

(2) Spraying of Plants before Harvest

The following compounds have been sprayed on growing potato plants to delay or prevent the sprouting of potatoes in storage: 2,4,5-trichlorophenoxyacetic acid (32), diethanolamine salt of maleic hydrazide (11), either the sodium salt or the diethanolamine salt of maleic hydrazide (unable to distinguish from the literature) (1, 4, 14, 15, 16, 17, 19, 21, 22, 23, 29, 32, 36, 37), methyl-1-naphthalene acetate (32), sodium 2,4-dichlorophenoxyacetate (26), sodium 2,4,5-trichlorophenoxyacetate (7, 32), sodium salt of maleic hydrazide (3), and sodium naphthalene acetate (7).

Of these chemicals the sodium salt of maleic hydrazide (MH-40) and the diethanolamine salt of maleic hydrazide (MH-30) have been used more than any other material for inhibiting sprouting.

In most cases, maleic hydrazide applied as a spray on potato plants "early" in the growing season caused plant injury and did not prevent sprouting. Sprays applied from 4 to 7 weeks before harvest did not cause plant injury and did inhibit sprouting. "Early"[3] applications of maleic hydrazide showed reductions in yield and deterioration in quality. Late applications showed no reduction in yield, with little or no deterioration in quality. However, Paterson in 1952 (21) reported late spray applications reduced yield and quality in his 1951 experiments, and he indicated a great necessity for proper timing of spray application if satisfactory results were to be obtained (21).

Simons and Scott in 1952 (32) observed that maleic hydrazide, methyl-1-naphthalene acetate and sodium 2,4,5-trichlorophenoxyacetate failed to cause any strong inhibitory effect on sprout production. However, Ellison and Smith in 1949 (7) reported sodium 2,4,5-trichlorophenoxyacetate and sodium naphthalene acetate were both effective in preventing sprouting when they were sprayed on plants just before the plant blossomed.

Fults *et al* in 1950 (13) reported that the sodium salt of 2,4-D, used as a basal plant spray when the tubers were ¾ inches in diameter, increased the red skin color of Red McClure potatoes with no reduction in yield. The following year Payne *et al* (26) used the above chemical in the same way and found that the tubers harvested from these plots produced significantly more sprouts, with a significantly lower average weight of sprouts, than the controls. There were no differences in stems per plant or in growth when the tubers were planted the following year.

[3]This concept of "early" treatment is before, or at the time of, tuber setting.

Methods

Source of Material

The Red McClure potatoes used were grown at the San Luis Valley Experimental and Demonstration Farm near Monte Vista, Colorado, in 1952 and 1953.

The plot design both years was a complete randomized block which included nine treatments and five replications. The plots were three rows wide and 100 feet long. The rows were 36 inches apart. All plants in each plot were treated and the middle row harvested for samples. The first four treatments were sprayed early, on July 28, 1952 and July 23, 1953 (48 days and 69 days, respectively, before harvest).

1. Maleic hydrazide (MH-40)[4] at 7 pounds per acre or 3 pounds active ingredients.
2. Alkanolamine salts (ethanol and isopropyl series) of 2,4-dichlorophenoxyacetic acid[5] at ½ pound per acre, acid equivalent.
3. Maleic hydrazide (MH-40) at 3 pounds per acre, plus the amine of 2,4-dichlorophenoxyacetic acid at ½ pound per acre sprayed 24 hours apart; the 2,4-D was applied first.
4. Same as treatment 3 except put on in the same spray.

The four treatments listed below were applied in the form of a spray late, on August 28, 1952 and August 24, 1953 (21 days and 33 days, respectively, before harvest).

5. Maleic hydrazide (MH-40) at 3 pounds per acre.
6. Alkanolamine salts (ethanol and isopropyl series) of 2,4-dichlorophenoxyacetic acid at ½ pound per acre.
7. Maleic hydrazide (MH-40) at 3 pounds per acre plus the amine of 2,4-dichlorophenoxyacetic acid at ½ pound per acre sprayed 24 hours apart; the 2,4-D was applied first.
8. Same as treatment 7 except put on in the same spray.
9. Control, no treatment.

The potatoes were planted on May 15, 1952 and May 7, 1953.

Harvest Dates and Storage Conditions

The crop was harvested September 14, 1952 and October 1, 1953 and placed in storage, in slatted oak crates, in the potato cellar of the Horticultural Department, Colorado A and M College at Fort Collins. The temperatures in this cellar average 40° F., but were somewhat higher than this average the first month of storage.

Methods of Sampling for 1952 and 1953

The selection of samples for yield data was accomplished both years by harvesting and weighing all the potatoes in the middle row of each of the 45 plots. Two, one-bushel crates of potatoes were selected at random, avoiding injured tubers, from the middle row of the plots for shipment to Fort Collins. At sampling time, 10 uniformly sized potatoes were selected from the crates of all plots and measured for skin-color. Ten readings were made on each potato or 100 readings for a plot.

[4]United States Rubber Company, Naugatuck Chemical Division, Naugatuck, Conn.
[5]Dow Chemical Company, Midland, Mich.

At the end of storage, when sprouting data were obtained, 10 tubers were selected at random from the crates of all plots. The weight of sprouts per tuber in grams was used as criteria of effects on sprouting. The tuber weights were also recorded.

Method of Measuring Red Skin-color

The Schaar Photoelectric Reflectometer Model 610, described in a previous paper (13), was used to determine differences in red skin-color. All measurements were made directly on uninjured skin surfaces of the potatoes.

Results

Effect of Treatment on Yields in 1952 and 1953

An analysis of variance of the yield data, for both years, indicated no significant difference in total yield, caused by any treatment.

Loss of Color in Storage
1952

The means of 500 galvanometric readings for the five replications of each of the nine treatments are shown in table 1. The data were subjected to an analysis of variance. Comparisons of mean color differences were also shown. The only significant differences found between treated and non-treated potatoes occurred with treatment 5 (maleic hydrazide used alone and applied late) and treatment 6 (2,4-D used alone and late). In both cases, the treatment produced tubers with significantly lighter skin color than the control.

These results are different from those observed during the previous four growing seasons (1947 to 1950, inclusive). During these seasons treatment with 2,4-D alone uniformly produced tubers with a darker red skin-color.

Results are understandable when the 1952 growing conditions are considered; *i.e.*, exceptionally dry from time of planting until early August. These experiences indicate that little or no effect on skin-color of Red McClure potatoes can be expected when sprays are used on plants in a growth retarded condition. This lack of effect is well known where 2,4-D is used as an herbicide on slow-growing plants with inadequate soil moisture.

1953

The data on the 1953 work are also shown in table 1. The only significant difference found between treated potatoes and the non-treated control was in the case of treatment 2 (amine 2,4-D used alone and applied early). The treatment produced tubers with significantly darker skin-color than the control. The results in 1953 with 2,4-D are in agreement with our previous work (1947-1950). The instrument readings in 1953 show that the potatoes were a darker color than in 1952.

Effect of Treatments on Sprouting

Data on the effects of treatment on sprout inhibition for the 1952 and 1953 crops are shown in table 2.

TABLE 1.—*The effect of maleic hydrazide and 2,4-D treatment on the skin color of Red McClure potatoes at harvest.*

Treatments	1952			1953		
Early	Treated	Control	Diff.[2]	Treated	Control	Diff.[3]
1. Maleic Hydrazide (MH-40) 3 lbs. per acre	60.4[1]	60.2	+0.2	44.4	44.2	+0.2
2. Amine 2,4-D ½ lb. per acre	59.8	60.2	−0.4	40.2	44.2	−4.0**
3. Amine 2,4-D + (MH-40) 24 hours apart	60.5	60.2	+0.3	43.7	44.2	−0.5
4. Amine 2,4-D + (MH-40) Same spray	60.9	60.2	+0.7	44.0	44.2	−0.2
Late						
5. Maleic Hydrazide (MH-40) 3 lbs. per acre	62.1	60.2	+1.9*	45.3	44.2	+1.1
6. Amine 2,4-D ½ lb. per acre	61.8	60.2	+1.6	43.3	44.2	−0.9
7. Amine 2,4-D + (MH-40) 24 hours apart	61.3	60.2	+1.1	43.9	44.2	−0.3
8. Amine 2,4-D + (MH-40) Same spray	60.1	60.2	−0.1	45.1	44.2	+0.9
9. Control— No treatment		60.2			44.2	

[1]Mean galvanometer units for 5 replications read on a Schaar photoelectric reflection meter, Model 610. The darker red the color the lower the readings.

[2]Minimum difference required in 1952 for significance at .05 level = 1.51
.01 level = 2.03

[3]Minimum difference required in 1953 for significance at .05 level = 1.81
.01 level = 2.44

*Significant at .05 level.
**Significant at .01 level.

1952

Early treatments produced better sprout inhibition than late treatments. Combination sprays, early or late, containing both 2,4-D and maleic hydrazide did not produce significantly better sprout inhibition than maleic hydrazide (MH-40) used alone. Early maleic hydrazide treatment produced significantly better sprout inhibition than late maleic hydrazide treatment and both were significantly better than the non-treated controls or 2,4-D.

1953

Again in 1953 early treatments produced a slightly better sprout inhibition than late treatments. Combination sprays, early or late, containing both 2,4-D and maleic hydrazide did not produce significantly

TABLE 2.—*The effects of maleic hydrazide and 2,4-D on sprout weights of Red McClure potatoes in 1952 and 1953.*

Treatments	1952 Grams of Sprouts per 100 Grams of Sample[1]			1953 Grams of Sprouts per 100 Grams of Sample		
Early	Treated	Control	Diff.[2]	Treated	Control	Diff.[3]
1. Maleic Hydrazide (MH-40) 3 lbs. per acre	0.01	3.40	—3.39**	0	3.76	—3.76**
2. Amine 2,4-D ½ lb. per acre	2.39	3.40	—1.01**	2.44	3.76	—1.32**
3. Amine 2,4-D + (MH-40) 24 hours apart	0.09	3.40	—3.31**	0	3.76	—3.76**
4. Amine 2,4-D + (MH-40) Same spray	0.07	3.40	—3.33**	0	3.76	—3.76**
Late						
5. Maleic Hydrazide (MH-40) 3 lbs. per acre	0.84	3.40	—2.56**	0.79	3.76	—2.97**
6. Amine 2,4-D ½ lb. per acre	3.44	3.40	+0.04	3.74	3.76	— .02
7. Amine 2,4-D + (MH-40) 24 hours apart	1.25	3.40	—2.15**	0.13	3.76	—3.63**
8. Amine 2,4-D + (MH-40) Same spray	0.95	3.40	—2.45**	0.13	3.76	—3.63**
9. Control— No treatment	3.40	3.40	———	3.76	3.76	———

[1]Each value is the average of 50 determinations. Ten tubers from each of five replicated field plots were used.

[2]Minimum difference required for significance in 1952 at the .05 level = 0.60
at the .01 level = 0.81

[3]Minimum difference required for significance in 1953 at the .05 level = 0.77
at the .01 level = 1.05

**Significant at .01 level.

better sprout inhibition than maleic hydrazide (MH-40) used alone. Here again, early maleic hydrazide treatment produced better sprout inhibition than did the late treatment, although both were significantly better than the non-treated controls.

DISCUSSION AND SUMMARY

One of the objectives of this investigation was to determine the most favorable techniques for using 2,4-D and maleic hydrazide on Red McClure potatoes to secure both the color advantages of the 2,4-D and the sprout-inhibiting properties of maleic hydrazide. The results indicate that the two chemicals may be used either alone or in combination and may also

be applied in the same spray or separately, and early or late with no significant yield depression caused by the treatment.

Under conditions of poor early season moisture, such as were present in the 1952 tests, the 2,4-D either alone or in combination with maleic hydrazide and applied either early or late failed to produce significant increases in color. In 1953 the only treatment which produced increased skin color was 2,4-D used alone and early. This is in agreement with our previous tests between 1947 and 1952.

Combinations of maleic hydrazide and 2,4-D produced no better sprout inhibition than did maleic hydrazide when used alone. This was true for both early and late treatments. Early treatment with maleic hydrazide or maleic hydrazide plus 2,4-D gave significantly better sprout inhibition than did late treatments in 1952, but not in 1953. This indicates a seasonal influence in an abnormally dry growing season. Early 2,4-D treatment significantly decreased the total weight of sprouts per 100 grams of tubers as compared with the controls in both 1952 and 1953. Previous tests in 1950 have shown that in spite of this, more sprouts are produced per tuber and when planted in the field there are no significant differences in either stand, number of stems per plant, or yield in the succeeding crop (26). These results would indicate that 2,4-D applied alone can be safely used on seed potatoes.

Probably the best procedure for obtaining high color and maximum sprout inhibition, where both are desired in the same lot of potatoes, is to use 2,4-D early[6] and the maleic hydrazide late. Maleic hydrazide and 2,4-D used together in the same spray or in separate sprays 24 hours apart, either early or late, have failed to produce significant color increases.

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[6]Our concept of "early" is at the time when tubers average ¾ inch in diameter. A rapid growth of the whole plant also seems necessary for maximum favorable results.

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IRISH POTATO POLLEN STORAGE[1]

J. R. KING[2]

The importance of a knowledge of the handling of pollen for pollination purposes has long proceeded the actual accumulation of that knowledge.

The viability and longevity of pollens have always been a vital factor in breeding technics. It is only the realization by breeders of their importance which is now increasing. The advantages in breeding technics of a measure of control over pollen viability are obvious.

Studies on pollen longevity during the past forty years have considered the roles of: temperature and/or humidity (1, 2, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 24, 25, 26, 27, 28), varying pressure (21, 22, 17), culture media (1, 23), and physiological conditions (3, 4, 5, 6, 17, 23).

METHODS

The Irish potato pollen storage tests reported on here were begun during the 1954 potato flowering season in Louisiana (April to early May). This is to be considered as a progress report, which is presented now in the event that certain results, to date, may be of value to some potato breeders during the coming breeding season. The particular purpose of the tests has been to determine the season-to-season longevity characteristics of Irish potato pollens; and, if possible, to contribute to the realization that storage of pollens can be, when needed, routine in potato breeding technics.

There are two general types of pollen storage—short-period and long-period. The first type is the storage of batches of pollen which are currently used for pollination. Vials of potato pollen will keep temporarily (after being dried)[3] in a household refrigerator, or in a similar storage place with a temperature roughly between 35 and 45 degrees Fahrenheit. The viability of Irish potato pollen below which the pollen should be considered unsatisfactory for field use, is an important problem still to be worked out; however, pollination during the 1954 and 1955 breeding seasons indicated that when pollens are strong they can be used repeatedly for a week or more before being replaced.

Long-period storage of pollen is concerned with the longevity of any batch of pollen over a period of months, or years, during which time it is not handled.

Six relative humidities in the five temperatures of 35, 40, 50, and 60 degrees Fahrenheit, and Room made up the thirty combinations of temperature and humidity used in the long-period storage tests reported on here. The one remaining storage environment was minus-30 degrees Fahrenheit[4], with no controlled humidity. Only eight pollens were used

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[3]King, J. R., 1955. "Pollen and Pollination Studies on Irish Potatoes". Amer. Potato Jour. Vol. 32: 7-15.

[4]This temperature was raised to minus-20° F. early in May, 1955. Recent viability tests (July, 1955) on 1955 spring pollens stored at the latter temperature indicate good longevity thus far. Future tests are to determine whether temperatures nearer zero Fahrenheit are as suitable for long period storage of potato pollens. Lack of storage facilities at such temperatures has delayed these tests.

in this first year's tests except for the sub-zero Fahrenheit environment, where 39 batches each from the 1954 and 1955 season have been stored.

The vials of pollen were stored in fruit jars. Humidity was maintained with sulphuric acid. Tests are now in progress which may show whether or not a gradual lowering of the temperature definitely affects the longevity of potato pollens stored at sub-zero degree Fahrenheit. Similar tests during the past year were inconclusive.

Viability checks based on germination percentages were made periodically, using 2 per cent agar—13.5 per cent sucrose culture medium. The percentages for the two most promising storage environments tested are shown in table 1. It is not necessary that the other storage combinations be listed in the table since they showed little, or no, promise for the purpose.

TABLE 1.—*Long Period Storage of Irish Potato Pollens.*

Storage Environ.	Pollens (Dates of Collection)	Germination Percentages			
		1954		1955	
		July	Oct.	Jan.	June
—30°F.[3]	Katahdin (Apr. '54)	....	....	8.5	6.0
"	Cherokee (Apr. 5, '54)	....	....	11.5	5.0
"	La Soda (May 1, '54)	6	....	....	....
"	Sebago (Apr. 7, '54)	....	....	0	0
"	Sdlg. 31-86 (Nov. 1, '54)	....	....	15	2.0
"	Sdlg. 92-23 (Apr. 11, '54)	....	....	8	4.0
"	Neb. 26.44-1 (Apr. 13, '54)	....	....	5	5.0
35°F.—RH 18.8	Cherokee (Apr. 5, '54)	11	9	7	0
" "	Sebago (Apr. 9, '54)	0	0	2	0
" "	Katahdin (Apr. 9, '54)	8	9	7	0
" "	Sdlg. 92-23 (Apr. 11, '54)	8	9	8	0
" "	Neb. 26.44-1 (Apr. 11, '54)	0	3	1	0
" "	Sdlg. 92-167 (Apr. 11, '54)	1	....	....	....
" "	Katahdin (Apr. 18, '54)	7	9	7	0
" "	La Soda (May 13, '54)	12	8	7	0

The absence of germination percentages at the beginning of the storage is due to the fact that the test had to be started during the rush of the spring breeding work and before a satisfactory culture medium for the pollens was worked out. It was then considered advisable for the stored pollens not to be handled until the planned three month check date. The value of this particular test, however, is not lowered by this shortcoming.

The results of these viability tests seem to indicate therefore, that, among the various storage environments used, longevity of the stored pollens has thus far, been best, by far, at the sub-zero Fahrenheit temperature[4] and second best at 35 degrees F. (Relative humidity of 18.8 per cent). Third best has been 35 degrees F. (Relative humidity of 27.4 per cent). Pollens in these three storage environments will be continued indefinitely, particularly in view of the lack of germination in June, 1955 of the pollens stored at 35° F. (18.8 Relative humidity)

I wish to call attention to the use of germination percentages as the so-called test of viability for these particular stored pollens, since therein lies a limitation which should be explained. The germination of Irish potato pollens on an artificial medium, contrary to that of some horticultural crops (such as the tree fruits and certain small fruits), seems very low. This is not uncommon; nevertheless, a problem in the handling of all pollens is the reliable determination of the viability of a batch of pollen for a particular time.There always exists in such a situation the possibility that the best culture medium and culturing technic have not been attained for the pollens tested; however, in these tests, various agars, and agar-sugars, or sugar solutions, alone, were tried, with varying pH's and under varying culture environments.

Potato pollen grains take up, selectively, certain stains when the latter are in an agar medium; and there is now the probability of the development of a stain test of viability which will replace the meaningless aceto-carmine "stainable" pollen interpretation of pollen potency.

The pollens of a number of horticultural crops (and certainly those of Irish potato which we have studied so far), however, react irrationally in germination tests for viability. The germination of potato pollens can be doubled or tripled at 60° F. as against 90 degrees; and different agars can cause wide variation in germination of the same batch of pollens. It is well known, furthermore, that differences in germination percentages regularly occur in different areas of the same culture or in different cultures on the same medium, whereas germination percentages of the same pollen may even seem to increase, or at least they fluctcuate, during a year's storage as shown in table 1. There are other examples of the inconsistencies of pollen behavior in a so-called artificial environment—not only for Irish potato but also for the pollens of certain other horticultural crops. The inconsistencies, however, seem excessive for potatoes.

Germination percentages of potato pollens can, therefore, be expected to give an indication that a pollen is living; but the erratic reaction of potato pollens to artificial media make these percentages necessarily not reliable in regard to the actual potency of a pollen at any one time, particularly in view of that potency in pollinations. The absence of germination in any particular culture of stored pollen, furthermore, is no proof, for the reasons given above, that the pollen is either all dead or too weak for field use.[5] The degree of incompatibility of a cross must, of course, be considered in pollinations; however, any doubt seems in favor of a potato pollen having greater potency than its germination percentage would lead us to believe.

It can be said, in conclusion on this subject, that even though the determination of the viability of pollens by germination on artificial media is not reliable, and is not consistent in results, the method is still the best. It will, and should, continue to be used until a better test is devised.

Let us now consider the longevity of some of the stored pollens as indicated by potency in field pollinations during the 1955 breeding season. Late spring frosts in Louisiana this year (1955) severely cut back the potato plantings at Baton Rouge; however, the breeding material finally

[5]See footnote (a) to table 2.

began flowering late in April—nearly a month late. The average maximum day temperature during the extent of the pollinations was 87.2° F., with a minimum of 65° F. and above for one-half of the nights. Pollen production and the viability of fresh pollens were far below those in 1954, when the breeding season extended from late March through April, and in cooler weather. Anthers were shriveled and dried to various degrees in nearly all varieties and selections, even in the soon-to-open buds. Pollen of several selections and of Katahdin variety which were collected in late March from a sub-station planting nearly free from frost damage was in far greater abundance and of higher germination percentage (10-14 per cent) than was that from the same selections and from Katahdin at Baton Rouge five to six weeks later (1-2 per cent). Only nine selections and varieties at the latter location produced pollen strong enough, and in sufficient quantity, for pollinations; and two of these produced no seed-balls.

Our thought, at the time of the pollinations, on the strong possibility of widespread failure in seed-ball development caused by excessive heat led to limited pollinations with stored pollens; however, the results from those which were used certainly did not warrant the caution, as shown in table 2.

The set of seed-balls from all pollinations at Baton Rouge made with 1955 pollens was 5 per cent, whereas the set from those made with stored (1954) pollens was 22.7. The average set of seed-ball from successful pollinations with 1955 pollen was 29.8 per cent, and the average set with stored (1954) pollens was 34.4 per cent.

These results appear very good as far as they go; however, it must be kept in mind: (1) that the season was particularly poor for the production of fresh pollen, (2) that in every pollination, various factors other than the potency of the pollen (such as, the degree of compatibility between the parents), influence the percentage set of seed-balls; and, finally, (3) that more extensive pollination with stored pollens (including those stored at 35° F.—18.8 R.H.) would have been desirable in the comparisons between current and dated pollens. For example, a sample of 13 month-old Cherokee pollen was sent by Air Parcel Post in late June, 1955, to the Plateau Experiment Station, Crossville, Tennessee. Pollinations onto U.S.D.A. Seedling 9656 resulted in a 15 per cent set of seed-balls with the stored pollen and a 30 per cent set with fresh Cherokee pollen[6].

We should not think, nevertheless, in doubt any longer about the practicality of season-to-season storage of Irish potato pollens and about the use of dated pollens in breeding. We must be concerned, instead, with the refinement of the methods involved and the practical application of information, which should continue to accumulate, on the storage of potato pollens. When fresh pollens are available and other limiting factors of a breeding season are favorable, plant breeders too often are little interested in, and give little thought to, the value of stored pollens; however, when, for some breeders, fresh pollens are suddenly not available or are weak and low in production (as was true for many selections and varieties at Baton Rouge in 1955) a stand-by supply of stored pollens (either at hand

[6]Appreciation for this cooperation is extended to Dr. T. P. Dykstra, Senior Pathologist, U.S.D.A. at Baton Rouge, and to his associates at Crossville.

TABLE 2.—*Seedball Set* and Seed Development** from Pollinations with 1954 (Stored) and 1955 Pollens at Baton Rouge*

Cross	Per cent S. B. Set	Average No. Seeds Per Seedball	Age of Pollen	Remarks
Cherokee x				
Sdlg. 31-86	22.2	Approx. 36	2 days	
Sdlg. 22-14	90.0	144	4 days	
Sebago x				
o.p.	.....	None	.....	
Sdlg. 31-86	47.0	5	2 days	
Sdlg. 22-194	45.4	5	2 days	
" "	11.3	5	4 days	
Self	22.5	None	13 mo.§	Pollen stored at sub-zero F.†
Sdlg. 22-14	8.4	1	10 days	
MSS-4.2 x‡				
Sdlg. 22-153	72.7	179	2 days	
Sdlg. 22-14	16.6	91	2 days	
Sdlg. 31-86 x				
Sdlg. 22-153	26.6	177	9 days	
Sdlg. 22-194	30.4	.....	9 days	
Self	4.5	42	7 mo.§	Pollen stored at sub-zero F.†
"	20.0	57	7 mo.§	
Katahdin	13.0	4	2 days	
Sdlg. 22-153 x				
Katahdin	6.2	102	16 days	
Sdlg. 22-194 x				
MSS-4.2‡	5.5	14	2 days	
Sdlg. 82-23	29.7	70	3 days	
Sdlg. 22-14	9.5	53	1 day	
MSS-4.2‡	7.6	None	1 day	
Sdlg. 12-92 x				
Sdlg. 22-194	66.6	52	2 days	
Sdlg. 92-167 x				
Sdlg. 92-23	95.6	89	12 mo.§	Pollen stored at sub-zero F.†
Kitting x				
Sdlg. 22-194	28.5	7	5 days	

Sdlg. — Seedling

*This table shows only crosses from which seedballs developed. It does not indicate that 25 combinations, involving 9 different female parents, produced no seedballs, nor that only 9 selections and varieties out of the 60-odd in the breeding block produced usable pollen.

**There was usually 8-10 per cent seed abortion from each combination.

†See footnote No. 4.

‡This is (S. acuale var Recoba x Katahdin) x Cl. B. 72., which was sent to Baton Rouge, La., from the Potato Introduction Station, Sturgeon Bay, Wisconsin.

§The 13 mo.-old stored pollens of Sebago and Sdlg. 92-23 both showed no germination before being used for pollination, while the 7 mo.-old pollen of Sdlg. 31-86 showed only 1 per cent germination.

or easily procured) can make the difference between success or failure in a season's breeding work.

The routine long distance shipment of viable potato pollen, the exchanges of pollen (either fresh or stored) among potato breeders, and the establishment of potato pollen collections for distribution among breeders are now within reach.

It is to be stressed, in conclusion, that there should be continuing studies on Irish potato pollination methods, on pollen handling, and on pollen characteristics. There are often wide varietal differences among pollens, and a stockpile of such information should be developed along with other varietal characteristics of Irish potatoes. The value of such information to potato breeding is obvious, and many problems are still to be worked out.

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OBSERVATIONS ON THE USE OF BAGS AND ON EMASCULATION IN POTATO POLLINATION[1]

J. R. KING[2]

The problems of bagging pistils before and/or after pollination, and the time-lapse between emasculation and pollination are always good for differences of opinions among breeders, particularly with reference to seed-ball set in the field.

The data in table 1 were compiled from tests carried out during the 1955 month-late spring potato breeding season in Louisiana. The maximum day temperatures between April 20th and May 20th averaged 87.2° F. with fifteen nights having a minimum of 65° F. and above.

Although the tests covered only about 1750 pollinations, certain results from this material are of interest, particularly in view of the unusually warm weather of the flowering season.

Only nearly-opened buds were emasculated; but the pollination of non-emasculated pistils included both nearly-opened buds and newly-expanded flowers.

One-pound brown paper bags were secured over the inflorescences by the conventional paper-clip method. Since the only intended purpose of the bags in these tests was to protect emasculated pistils from sun heat during the day or from early morning dampness, air holes were torn in the sides of them. The time of bagging and emasculation is designated in the table, as is also indicated the combinations of emasculation and bagging. No further explanation regarding methods used in the tests seems necessary.

There was, as expected, no advantage in bagging pistils which had been emasculated and pollinated during mid-to-late afternoon; however, the bags were a protection for both emasculated non-pollinated and emasculated pollinated pistils during the excessive heat of some days. Non-covered emasculated pistils were burned on particularly hot days, whereas covered pistils remained fresh and appeared receptive. Limited data not included in table 1 indicated that bags can be left on pollinated pistils for several days, or more, with little, if any, adverse effect on set of seed-balls.

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The results of these limited tests indicate, furthermore, that as far as the material tested is concerned, pollinations on emasculated pistils set a higher percentage of seed-balls than did those on non-emasculated pistils[3] regardless of whether there was, or was not, a time-lapse between emasculation and pollination or whether emasculation and/or pollination were performed in the morning or afternoon.

These results, however, must take into consideration the fact that comparative percentages of seed-ball set in pollination tests are influenced by the degree of compatability in the parental combinations of the pollinations.

[3]Comparisons made in 1954 indicated similar differences.

TABLE 1.—*Set of seed-balls in tests on various times of bagging and emasculation of potato pistils.*

	Emasc. 3:30-5:00 P.M. and Poll. Immediately afterwards	Emasc. 3:30-5:00 P.M. and Poll. 8:00-9:30 Next Morning	Emasc. 6:00-9:30 A.M. and Poll. 3:30-5:00 P.M. Same Day	Emasc. 3:30-5:00 P.M. and Poll. Same Period Two Days Later	No Emasc.; Poll. 3:30-5:00 P.M.	No Emasc.; Poll. 6:00-7:00 A.M.
	Per cent Set	Per cent Set	Per cent Set	Per cent Set	Per cent Set	Per cent Set
No Bags Used	95.6				10.6	6.2*
Bagged after Emasculation, but Not Rebagged after Pollination		42.1	18.3	19		
Bagged after Emasculation; Bags Left on until Evening, or Overnight, Following Pollination		14.8	22.3			

*About one-half of all of the pollinations in the tests, covering nearly all of the 55 parental combinations, followed this procedure.

NEWS AND REVIEWS

SEED POTATO INSPECTION AND CERTIFICATION IN NEW YORK

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In 1911 Dr. W. A. Orton visited Europe where he learned to differentiate a number of potato diseases which had previously been confused. In 1913 he published Bull. 47 of the U. S. Department of Agriculture, "Lessons for American Potato Growers from German Experience." A half page in this bulletin describes very briefly the system of certification as used in Germany and advocates a similar system for the United States. Early in 1914 he published Bull. 64: "Potato wilt, leaf-roll and related diseases," containing rather detailed descriptions and illustrations of leaf roll, mosaic, curly dwarf and streak. In this bulletin he refers frequently to severe losses caused by a leaf-roll outbreak in the Greeley district of Colorado and in western Nebraska in 1911 and 1912 and gives a rather detailed description of this outbreak with several illustrations. It appears to the present writer that the disease involved was psyllid yellows, rather than leaf roll. Thus it may be that much of the impetus to the development of a certification system in this country was derived from an outbreak of a disease not controllable by certification methods. Curly dwarf and streak we recognize today as forms of rugose mosaic. Possibly spindle tuber and yellow dwarf were also involved. Orton clearly recognized the hereditary nature of these diseases but considered leaf roll as not communicable.

In 1914 Orton arranged for Dr. Otto Appel to come to this country and made visits with him to most of the northern states. In New York these two men spent several days visiting potato fields in company with Barrus, Mix and Reddick of the plant pathology department. There were also in the party, at least part of the time, some county agents, New York farmers, Wm. Stuart of U.S.D.A., T. C. Johnson of the Va. Truck Expt. Sta., Norfolk, Thos. Manns, Delaware Expt. Sta., W. J. Morse, Me. Sxpt. Sta., B. F. Lutman, Vt. Expt. Sta., and E. H. Brigham, Commissioner of Agriculture of Vermont. Appel showed them plants affected with mosaic, leaf roll, curly dwarf and streak, which the New York delegates had not previously known well. During evenings they discussed ways of combatting these diseases. Emphasis was placed on obtaining seed tubers from healthy plants and Appel told how this was facilitated by the German system of inspection and certification. Before the end of the trip Orton suggested to Barrus that such a system be started in New York soon. Appel was somewhat disturbed by the fact that he was unable to find mosaic in western New York (where potatoes of the Rural type were mainly grown) while it had been fairly abundant in most fields in Northern New York (where Green Mountain was the prevalent type).

During the summer of 1915, Barrus inspected a number of potato fields for practice and the following spring arranged for an inspection service with E. V. Hardenburg of the Department of Vegetable Crops. During 1915 fields of 66 growers were inspected, with cooperation from county agents, who furnished much of the transportation and made contacts with growers. Most of these growers were members of one of three local associations. A plan for certification was drawn up for adoption by the newly formed New York State Potato Association but this was not adopted until too late to put it into operation in 1915. It was put into operation in 1916 when inspections were made for 35 growers with 342 acres of which 156 acres belonging to 29 growers passed. In

1917 there were 78 growers with 428 acres of which 337 acres were passed. One of the problems in the early years was the large number of varietal names being used for what appeared to be the same variety. This was solved by classifying most of them into types and using the type names, Green Mountain, Smooth Rural and Russet Rural.

The first standard adopted allowed 15 per cent mosaic and 10 per cent of one or more of a number of diseases including leaf roll at the first inspection but only 5 per cent mosaic or 1 per cent leaf roll at the second inspection. Emphasis was on roguing as it was not known at that time how these diseases spread.

During the early years, certification was by the New York State Potato Association and inspections were made by their inspectors, who were, however, members of the College staff or graduate students. In 1919 the association entered into an agreement under which the Department of Plant Pathology in the College of Agriculture at Cornell University took full charge of the inspection. In 1921 the Association reorganized as the New York Cooperative Seed Potato Association, Inc. This association, in addition to certifying the seed was to act as an advertising and marketing agency and hire a manager. Since some of the certifying growers had their own sales organization they objected to being forced to subsidize their competitors and asked to be allowed to certify their own potatoes on the basis of college inspections. During 1921 there were two certifying agencies and in 1922 ten, all receiving inspection service from the College. One additional organization obtained inspection from Syracuse University and certified their own seed. This multiplication of agencies was recognized as undesirable and led to the organization in 1922 of the New York Seed Improvement Cooperative Association, Inc., which would take over all certification for potatoes as well as for other crop seeds but would do no selling or advertising beyond publishing lists of certified seed fields. After 1922 the College gave no inspection service except to members of that association. In 1933 there was the first legal enactment defining the term certified as applied to seed in New York.

In 1923 samples of 105 tubers each were solicited from seed sources being used and these were planted on the college farm. The following year submission of such samples was made a requirement. In 1925 a tolerance for virus diseases in this sample plot was established.

Tests of New York seed samples in the south were first made in 1925. A test was made each year thereafter of samples voluntarily submitted until 1935, when samples from all fields certified were required to be tested.

Inspectors employed in the early days were:

W. M. Peacock, 1915-1917
F. M. Blodgett, 1917-1918
R. J. Haskell, 1916
E. V. Hardenburg, 1917-1922
I. H. Vogel, 1918
C. R. Stevenson, 1918-1919
H. H. Clum, 1920-1921
L. M. Fenner, 1920-1923
Charles Chupp, 1920-1921
S. E. A. McCallan, 1923-1928

General supervision of the work was by M. F. Barrus from 1915 to 1923 except in 1918 when H. H. Whetzel acted. Supervision was taken over by K. H. Fernow in 1924 who has acted since that time.

The number of growers engaged in potato certification showed a fairly steady increase from 1916 with 35 to 1930 with 248, after which the number gradually declined to 106 in 1942. The acreage certified increased, with a few

minor dips, from 156 acres in 1916 to 2855 in 1931, then dropped gradually to 1365 in 1939. A marked increase in the war years reached a peak in 1945 with 4446 acres.

During the first 10 years a rejection of 30 to 50 per cent of the fields was quite usual, with mosaic usually the major cause and leaf roll next. During the thirties yellow dwarf was a frequent cause of rejection. Fields were first rejected for ring rot in 1940.

In addition to those previously mentioned advice and encouragement were received from F. C. Stewart and F. A. Sirrine of the Geneva station and H. G. Sands of the State Department of Agriculture.

A considerable aid to securing uniformity in inspection and diagnosis of disease in the northeastern states was a series of annual meetings of potato inspectors at Freehold, N. J., started in 1926 under the leadership of W. H. Martin.

EARLY SEED POTATO WORK IN MINNESOTA

A. G. Tolaas
State of Minnesota
Department of Agriculture

In 1917 we tried to get a seed potato law passed by our Minnesota State Legislature without success. At that time I was Extension Plant Pathologist in the State. Any potatoes that were not sold as table stock were sold as seed. Dr. William Stuart had just published his bulletin on Classification of American Potato Varieties which was a great help in straightening out the variety situation. While Extension Plant Pathologist we made a survey of potato varieties being grown in the state and found that potatoes were being grown under some seventy different names. As you will recall Dr. Stuart had tested hundreds of named potatoes and in his classification sorted them out into eleven varietal groups. Using this classification as a guide, we adopted seven of them since most of the seventy fitted into one or the other of those adopted. Potatoes were not only sold under all of these seventy names but often the varieties were mixed and often one variety was sold by another name according to the desires of the customer. About the only varieties sold by name were: Early Ohios (most important variety in the Red River Valley), Bliss Triumphs, and some Cobblers, which had recently been introduced in the State. However since nothing was known about the viruses, even the best of the potatoes were unsatisfactory bringing complaints from any area where they were planted. There was no particular attempt at grading since this was before any attempt was made to establish Federal grade standards.

In 1919 our State Legislature became convinced that something had to be done so they passed a Seed Potato Certification Law which provided for a Seed Potato Certification Board consisting of the President of the State Potato Improvement Association, the Dean of the Agricultural College (both ex-officio) and three growers appointed by the Governor. Because of the regulatory features involved the work was transferred to the State Department of Agriculture (recently established) in 1921 where the work has been carried on ever since.

By this time we felt the variety situation had been fairly well straightened out and we were learning a little about the recognition of mosaic and leaf-roll. There was plenty of spindle tuber which was considered as "running out" due to keeping and planting the same stock year after year. It wasn't until the discovery that spindle tuber was due to a virus (1923) that we commenced to make any headway against it.

Both Dr. E. M. Freeman and Dr. E. C. Stakman, were instrumental in seeing to it that seed potato certification was established in this State. During my four years (1915-1919) I was doing quite a lot of extension work with potatoes and Stakman thought I should take the job of organizing and administering the set-up as provided by the Legislature. I accepted the responsibility and have been at it ever since. Rules and regulations as provided by the law were adopted more or less according to the provisions discussed at the Philadelphia conference. In 1927 the law was revised and has been amended from time to time to fit changing conditions.

The two preceding articles on seed certification were prepared for publication in the 1956 Potato Handbook, but are published here because of the lack of space. Ed.

HOLLAND HAS ITS WASHED AND PACKED POTATOES

Holland recently acquired a new industry. In September a couple of firms began washing potatoes and delivering the washed product in small size packages (5 kg).

It was rather long before a regular production was achieved. This was preceded by several years of experimentation and scientific investigation. Problems such as drying, grading, the washing itself, the type of packing and, last but not least, the price of the end-product, formed subjects for investigation and discussion. But now the time has come for production to begin. Besides loose washed potatoes, which were already on the market in 1953, the washed potatoes are also sold in two types of small-size packing. One firm uses paper bags with a window of mesh-work, to make ventilation possible. The other firm employs polyethylene bags to pack its product in. These are printed and have little holes punched in them for ventilation. In principle there is not much difference between the production methods followed by the two firms. In the case of one firm automatization is somewhat further advanced than with the other. When we recently paid a visit to the Dutch potato-washing industry our photographer took several shots.

The potatoes which had been purchased by the firm's buyers from nearby farmers were loosely tipped in the storage place. Storage space had been made both in the hall and outside this latter. However, the peculiarity of this storage space is that it is so equipped that only one man is required to render possible transportation to the machinery installed in another part of the building. Gutters do the rest. With slight movements of his hands the man in the storage place directs the potatoes into the gutter. The quickly flowing water entrains the potatoes and takes them to a tank alongside the machinery. A rotating hoist scoops the potatoes out of this tank and takes them up to a grading sieve. The

meshes of this sieve are so large that potatoes with dimensions less than 38 mm. (1½") fall through. This "small fry" is therefore sorted out and eliminated from further processing. From the grading sieve the potatoes go on the washing machine. Brushes situated behind one another roll the blemishes off the potatoes, whilst spray nipples, through which water is forced at high pressure and which are directed on the potatoes, attend to the washing proper. The potatoes roll on and are transferred by the rotating brushes to the drying machine. Here, too, there are rollers, but these are lined with water-absorbent material, which do the work. The water which the rollers remove from the potatoes is extruded at the bottom of the machine by counter-rollers. Up to now only one person has been involved in the washing process. Now things change, for the potatoes come from the drying machine on to the grading belt. Four workers remove the imperfect potatoes from the grading belt. They throw these into a funnel in front of them, which is mounted on the machine. The potatoes fall through the funnel into another gutter through which the washing water which has been released flows. *Via* a hoist the waste disappears from the building and ends up on a dump, which is destined for the potato flour factory or the food troughs of livestock. However, let us follow the washed potatoes from the grading belt to the packing machines. Here again we have a high degree of efficiency and automatization. From the grading belt the potatoes enter the storage bins of the packing machines. Rotating belts lift the potatoes into the bags. When these have reached their correct weight the belts stop. The bag is quickly replaced, the full bag being placed on the table behind the packing machines Skilled hands attend here to the closing of the bags.

The product is now ready for shipment. A storehouse for the end-products is not yet in use at the washeries. Owing to the great domestic demand it rarely occurs that the product stays on the firm's premises longer than one day.

At the beginning of this article we said that in past years there were many investigations and discussions. In particular the price often formed a subject for discussion.

It will be obvious that washing, additional grading and packing, costs money. Many people in Holland were of the opinion that the public would not be prepared to pay this extra amount, although, of course, it is offset by considerable advantages. However, the public proved quite prepared to spend a little more for washed potatoes in small-size packages. It cannot yet be determined at what rate the production of washed and packed potatoes will expand. On the other hand, it may be noted that various other potato firms are following present developments with great interest. When building new business premises, firms often make allowances for the fact that within the not too distant future they will be undertaking washing themselves. The scientific people at Wageningen are also very interested in potato-washing. From the beginning they have had close contact with the existing washeries and have sought and found solutions for various problems. As we write the Institute for Potato Storage at Wageningen is constructing a trial plant, in which research will be continued in close cooperation with the washing firms already in operation.

—*Reprinted from* POTATO NEWS FROM THE NETHERLANDS, Vol. 4, No. 3

THE INDEX

TO THIS VOLUME HAS BEEN REMOVED FROM THIS POSITION AND PLACED AT THE BEGINNING OF THE FILM FOR THE CONVENIENCE OF READERS.

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